High-Resolution 3D Shape Matching with Global Optimality and Geometric Consistency

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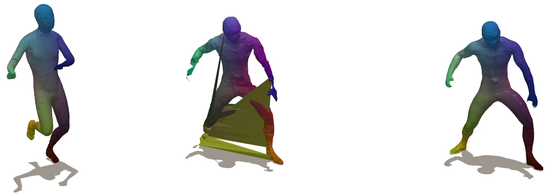
Code&Paper

Geometrically Consistent Shape Matching

Goal: finding correspondences between two *non-rigidly deformed 3D shapes* $\mathcal{X}$ and $\mathcal{Y}$ while preserving the *neighbourhood relations* of surface elements (which is essential for downstream tasks).



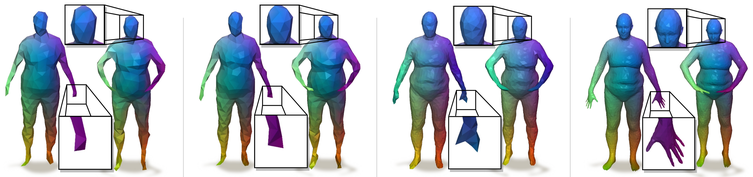
Source Geometric Consistency ✗ Geometric Consistency ✓

Applications: Texture transfer, protein alignment, shape completion, ...

Our Contributions

- We propose a **geometrically consistent** 3D shape matching algorithm that scales to practically relevant resolutions (up to **10,000 triangles**).
- We propose a novel formalism to find **globally optimal** matching of a set of **patches** (defined on the source shape) to the target shape.
- We empirically show that our approach **scales substantially better** compared to existing geometrically consistent approaches.

Comparison to Other Works

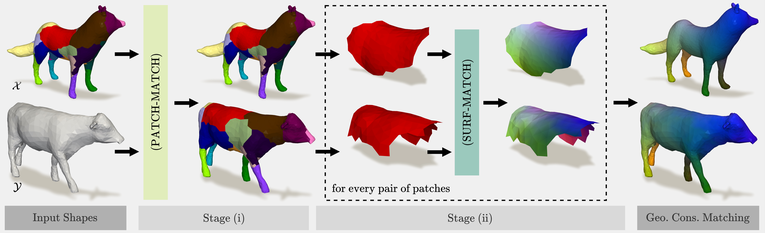


DiscoMatch [1]: max 750* △ | SM-Comb [3]: max 1,000 △ | GeCo [2]: max 3,000 △ | Ours: max **10,000** △

Our approach scales almost an order of magnitude better than the prior best method GeCo [2]. This allows to match shapes with more geometric fidelity.

SuPa-Match

Overview



Details

1. Define a set of patches *only* on shape $\mathcal{X}$.
2. Solve ***PATCH-MATCH*** to transfer patches from shape $\mathcal{X}$ to shape $\mathcal{Y}$.
3. For every pair of corresponding patches, consider each *triangle* of $\mathcal{X}$ as a *patch* and solve ***SURF-MATCH*** to obtain dense correspondences.
4. Aggregate all solutions of ***SURF-MATCH*** to obtain dense globally geometrically consistent correspondences.

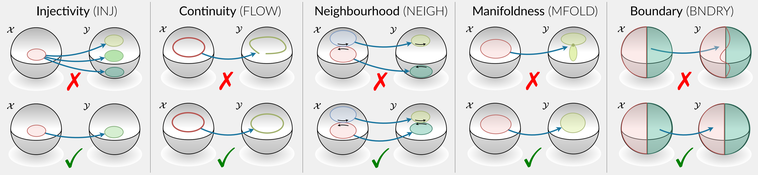
PATCH-MATCH

$$\min_{x \in \{0,1\}^{\mathcal{E}_{\mathcal{P}}}} c^T x \text{ s.t. } \text{(INJ), (FLOW), (NEIGH), (MFOLD)}$$

SURF-MATCH

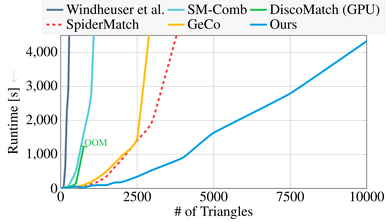
$$\min_{z \in \{0,1\}^{\mathcal{E}_{\mathcal{P}^\triangle}}} (d + \lambda r)^T z \text{ s.t. } \text{(INJ), (FLOW), (NEIGH), (BNDRY)}$$

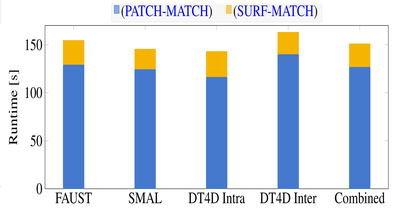
x, z: indicator of matching elements (product edges), c, d: deep matching cost, r: orientation-preserving regulariser, λ: weight of regulariser



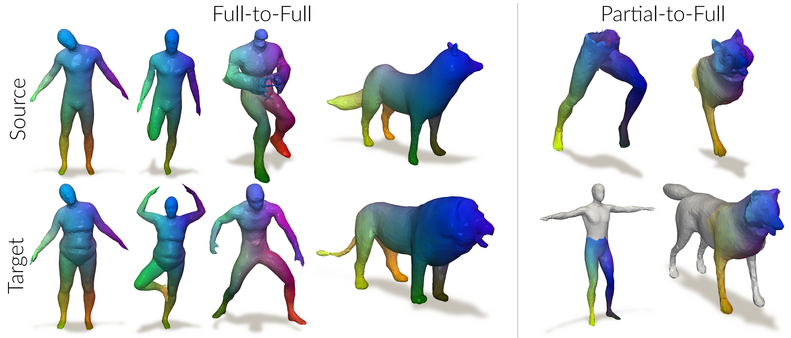
Results

Runtime analysis

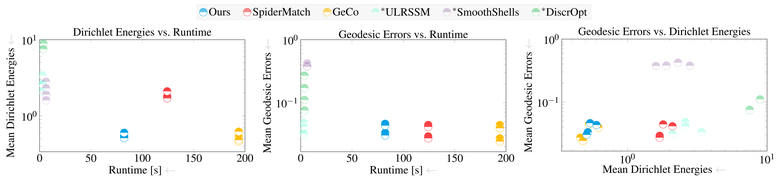




Qualitative results



Quantitive results



References

[1] Paul Roetzer, Ahmed Abbas, Dongliang Cao, Florian Bernard, and Paul Swoboda. Discomatch: Fast discrete optimisation for geometrically consistent 3d shape matching. In *ECCV*, 2024.
[2] Paul Roetzer and Florian Bernard. Fast globally optimal and geometrically consistent 3d shape matching. In *ICCV*, 2025.
[3] Paul Roetzer, Paul Swoboda, Daniel Cremers, and Florian Bernard. A scalable combinatorial solver for elastic geometrically consistent 3d shape matching. In *CVPR*, 2022.

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